ROUTE SHEET
PRNC-NRL-10-863 (Rev. 9-54)

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CODE	DATE	INITIALS	PUR-POSE	REMARKS
7100	4/14	HF		
7102	4/14	ESL		
7000	4/17	K		
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4000	4-17	P	6	
3000	4/17	[illegible]		
1525	4/17	[illegible]		
1000	4/20	[illegible]	1	
~~1040~~				~~Show green~~
5100	5/4	acc		Show Green
1522	4/20	[illegible]		
4006 5000	5/14	[illegible]	1	Show Green
1040	5/18 5-18	A	1	show green
4010	5/15	J.M.		MAY 15 1959
1523				

INSTRUCTIONS

Prepare 2 copies of this route sheet and forward ALL copies together with necessary correspondence and other documents.

PURPOSES

1. FOR INFORMATION
2. FOR APPROVAL
3. PREPARE REPLY
4. PREPARE ENDORSEMENT
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FROM: NRL to NASA

DATE OF MATERIAL:

BRANCH IDENT. SYMBOL: 7100-124

ORIG. IDENT. SYMBOL (Mail Room Fill in): 3799

DIVISIONS DO NOT FILL IN

DATE MAILED: 1 APR 1959

FILE NO. R06-29

SUBJECT: Fwdg. of Proposal for a Radiation Monitoring Satellite to [redacted] NASA

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NAVY-DPPO PRNC, WASH., D.C.

[redacted]

7100-124:HF:ms
SER: 3799
20 APR 1959

[redacted], Jr.
Assistant Director for Space Science
National Aeronautics and Space Administration
1512 H Street, N. W.
Washington 25, D. C.

Dear [redacted]:

The accompanying proposal describes a radiation experiment which the Atmosphere and Astrophysics Division of NRL wishes to conduct in a NASA launched satellite. We are prepared to begin work as soon as NASA approves the proposal and transfers the requested funds to NRL.

We shall be happy to discuss details of the proposal with members of your staff.

Sincerely yours,

[redacted]
Director of Research
By direction of the Director

Encl:
(1) Proposal for a Radiation Monitoring Satellite

[redacted]

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Proposal for a Radiation Monitoring Satellite

Prepared by

The Atmosphere and Astrophysics Division

of the

U. S. Naval Research Laboratory

1. INTRODUCTION

It is proposed to instrument a satellite with narrow band detectors covering as many significant wavelength regions as possible, within the limitations of space, weight, and telemetry. Observations would be made of (1) the sun, (2) the night airglow, (3) the day airglow, and (4) the aurora. Observing time would be split between day and night. The solar radiations monitored would be principally those in the x-ray and ultraviolet regions. These radiations are responsible for the ionization and much of the heating of the upper atmosphere. The study of such radiations should permit direct correlations of ionospheric behavior with the effective solar radiations. The measurements should also detect variations in solar emissions and permit correlations between the ionizing emissions and visible solar phenomena such as flares, surge prominences, and plage activity levels. Airglow and auroral emissions would be

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mapped both day and night. The manner in which the airglow and auroral emissions would be scanned should permit determinations of the heights of the emitting layers. The attenuation of solar wavelengths observed through the atmosphere should provide information about the vertical distribution of various atmospheric constituents.

2. SCIENTIFIC EXPERIMENTS

The daytime measurements proposed for the radiation satellite are listed below. All experiments will be designed for an expected life of one year.

DETECTOR	CHANNEL FREQUENCY	WAVELENGTH REGION (Angstroms)	DETECTOR
		Solar Radiations	
1	22 kc/s	.05 - 0.5	Scintillator
2	2.3	1 - 6 High Sensitivity	Ion Chamber
3	1.7	1 - 6 Low Sens.	Ion Chamber
4	2.3	2 - 8 High Sens.	Ion Chamber
5	1.7	2 - 8 Low Sens.	Ion Chamber
6	1.7	8 - 20 High Sens.	Ion Chamber
7	2.3	8 - 20 Low Sens.	Ion Chamber
8	2.3	44 - 60 High Sens.	Ion Chamber
9	1.7	44 - 60 Low Sens.	Ion Chamber
10	2.3	200 - 700	Ion Chamber

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DETECTOR	CHANNEL FREQUENCY	WAVELENGTH REGION (Angstroms)	DETECTOR
		Solar Radiations	
11	1.7 kc/s	200 - 900	Ion Chamber
12	2.3	200 - 1160 High Sens.	Ion Chamber
13	1.7	200 - 1160 Low Sens.	Ion Chamber
14	2.3	1050 - 1350 High Sens.	Ion Chamber or Photocell
15	3.0	1050 - 1350 Low Sens.	Ion Chamber
16	3.9	1050 - 1350 back scatter	Ion Chamber
17	2.3	1230 - 1350	Ion Chamber
18	1.7	1425 - 1500	Ion Chamber
19	2.3	1600 - 1800	Photocell
20	1.7	2000 - 2500	Photocell
21	2.3	3000 - 5000	Photocell
22	1.7	7000 - 12000	Photoconductor
23	1.7	Optical Aspect	Photocell or Photoconductor
24	2.3	Earth Cell	Photocell or Photoconductor
25	1.7	Magnetic Aspect	Single Axis Magnetometer
26	2.3	Temperature Monitor Voltage Monitor	Thermistor
		Day and Twilight Airglow	
27	1.7	3914 N_2^+	Photomultiplier + Filters

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DETECTOR	CHANNEL FREQUENCY	WAVELENGTH REGION (Angstroms)	DETECTOR
		Day and Twilight Airglow	
28	2.3 kc/s	2600 - 2900	Photomultiplier + Filters
29	1.7	7619 O_2	Photomultiplier + Filters
30	2.3	6300 OI	Photomultiplier + Filters
31	1.7	6563 $H\alpha$	Photomultiplier + Filters
32	2.3	5577 OI	Photomultiplier + Filters
33	1.7	5893 Na-D	Photomultiplier + Filters

The nighttime scientific experiments will include the following:

DETECTOR	CHANNEL FREQUENCY	WAVELENGTH REGION (Angstroms)	DETECTOR
34	22 kc/s	.05 - .5	Scintillator
35	22	2.0 - 8.0	Ion Chamber
36	1.7	200 - 1160	Ion Chamber
37	3.9	1050 - 1350 back scatter	Ion Chamber
38	2.3	1230 - 1350	Ion Chamber
39	1.7	1425 - 1800	Photocell
40	2.3	2600 - 2900	Photomultiplier + Filters

DETECTOR	CHANNEL FREQUENCY	WAVELENGTH REGION (Angstroms)	DETECTOR
41	1.7 kc/s	3914 N_2^+	Photomultiplier + Filters
42	2.3	3000 - 5000 (Zodiacal light)	Photomultiplier + Filters
43	1.7	5577 OI	Photomultiplier + Filters
44	2.3	5893 Na D	Photomultiplier + Filters
45	1.7	6300 OI	Photomultiplier + Filters
46	2.3	6563 Hα	Photomultiplier + Filters
47	1.7	7619 O_2	Photomultiplier + Filters
48	2.3	8000 - 11000 OH	Photomultiplier + Filters
49	1.7	1 - 2 OH	Photoconductive cell + Filter
50	1.7	Magnetometer	Single Axis Magnetometer
51	2.3	Earth Cell	Photocell or Photoconductor
52	3.0	Sunrise Cell	Photocell or Photoconductor

3. INSTRUMENTATION TECHNIQUE

The recovery of data from the solar radiation satellite would be accomplished through the use of a five channel telemetering system triggered on command from a telemetering ground station. The satellite would carry the following electronic equipment:

1. A low powered crystal controlled transmitter operating at ~108 mc for tracking purposes. This transmitter would operate continuously at 10 milliwatts.

2. A high power telemetering transmitter operating for nine minutes following interrogation. Output power is 4 watts at 105 mc. The transmitter would be AM modulated for five sub-carrier oscillators operating at 22 kc, 3.9 kc, 3.0 kc, 2.3 kc, and 1.7 kc.

3. A two channel command receiver operating continuously. Upon receiving the proper code, the circuit would turn on and connect either the Solar Experiment or the Nighttime Experiment to the telemetering transmitter.

4. Four commutators to connect detector output channels to sub-carrier oscillators. Also one sub-commutator to monitor temperature and voltage.

5. A calibrator to provide periodic in flight calibration of each of the five sub-carrier channels.

6. Fifty-two amplifiers to match detector outputs to telemetering inputs.

7. Fifty-two detectors.

8. Thermostatically controlled gas and crystal oven.

9. One power plant consisting of solar cells and Ni-Cd storage cells. The power plant would deliver an average of 3.5 watts to the electronics.

The general method of making measurements would be based on utilization of satellite spin as a means of modulating the incident solar flux and scanning the atmospheric emissions. The dc amplifiers coupling the radiation detectors to the sub-carrier oscillators would be feed-back amplifiers with a frequency response substantially faster than the spin rate of the satellite, so that the radiation data would not be integrated over a roll. The nighttime experiments would utilize scans by relatively narrow angle-of-view detectors.

The solar detectors would primarily consist of ion chambers and photocells. Most of the x-ray detectors would be vacuum tight ion chambers fitted with thin windows and utilizing inert gas or nitrogen fillings. In the spectral bands where no suitably transparent windows are available, i.e. between 100 and 1050 A, low pressure free flow ion chambers would be used. These ion chambers would be supplied with vapor obtained from reservoirs carried in the satellite. A free flow ion chamber would probably be used in the 1425 - 1500 A band, where photochemical decomposition of the ionizable gas is particularly severe. The longer wavelengths, i.e. those between 1600 and 5000 A would be monitored by photoemissive cells containing surfaces of the CsI, Rb_2Te and Cs_3Sb type. In the infrared, a photoconductive cell may be used. Aspect corrections would be made on the basis of information furnished by an optical aspect system which measures the angle between the rocket spin axis and the sun. A magnetic aspect system is also planned to measure the angle between rocket spin axis and local magnetic field. The combination of solar aspect and magnetic aspect permits total satellite aspect reduction. For the daytime experiment total aspect is important for analysis of the back-scattered Lyman-alpha distribution. This Lyman-alpha glow measurement would be made by utilizing a set of nine collimated ion chambers connected in parallel and driving a single electrometer amplifier.

4. SATELLITE DESIGN

The satellite would be designed with the major moment of inertia corresponding to the direction of spin; ie. similar to a flat cylinder or octagon with the mass concentrated near the rim. All solar detectors would be mounted looking out perpendicular to the axis of spin. All nighttime and day airglow detectors would be paired at diametrically opposite positions and directed at 45 degrees to the spin axis. The satellite may contain a liquid damper to suppress motion about axes other than that corresponding to the principal moment of inertia. The diameter of the cylinder or octagon should be about 40 inches, the height of the main structure should be about 24 inches with possible lightweight extensions for additional solar cells, if needed. The satellite would contain an insulated thermostated section for storage of volatiles and for minimizing temperature drift of transmitter crystal frequencies.

5. ORBIT AND ALTITUDE REQUIREMENTS

The orbit requirements are listed below:

1. Perigee $>$ 350 miles
2. Apogee $<$ 600 miles
3. Spin axis perpendicular to equator $\pm 5^{\circ}$
4. Plane of orbit to include Sun $\pm 30^{\circ}$
5. Initial spin frequency = 0.5 ± 0.1 revolutions/second

6. DATA RECORDING REQUIREMENTS

The data should be recorded at 15 inches per second on magnetic tape. After the first two weeks of operation, data recording may be reduced to about three nine-minute recordings of satellite signals per day, two recordings being made at sunlit passes of the vehicle and one at night. During unusually active solar conditions recordings would be requested to cover as much flight time as possible. At such times it would be expected that not less than 20% of the flight time would be recorded.

7. TELEMETRY

The antenna system would consist of a turnstile antenna fed from a hybrid junction which permits the antenna to serve as a radiator for both transmitters and a pick-up device for the command receiver without serious interaction between the units. The tracking transmitter would be similar to the Vanguard units. The telemetry transmitter would consist of a crystal controlled oscillator and a power amplifier which is amplitude modulated with five sub-carrier oscillators. The circuit techniques for lightweight transistorized transmitters developed in the Vanguard program should be directly applicable here within the 100 - 500 mc/sec range. A four watt power amplifier may be achieved by parallel operation of transistors or in the near future it may be expected that high power transistors will be available for this frequency range. An over all efficiency of 25% is expected for this application. The Vanguard command receiver could be used in its present state.

8. POWER REQUIREMENTS

A. On Command

Telemetering transmitter input power	16 watts
Experiments	6
Modulator	1
Total power on command	23 watts

B. Continuous

Tracking transmitter	.1 watt
Detectors	1.0
Command receiver	.06
Total continuous power	1.16 watts

Duty cycle on command - 10%

Average power requirement - 2.3 watts

Total power required

Continuous	1.16 watts
Command	2.3
Total	3.46 watts

C. Solar Power Supply Design

Solar constant - 100 milliwatts/cm^2

Efficiency - 8%

Power output - 8 milliwatts/cm^2

Area required - 430 cm^2

Allowing a 25% decrease in output for high temperature ($\sim 60^{o}C$) operation and 25% decrease in transmission of windows after prolonged bombardment by meteorites, brings the required area up to 670 cm^2.

Total area for the spinning satellite = 4 x 670 cm^2.

This requires a solar cell strip four inches high around the circumference of a 40-inch diameter package. Power will be stored in nickel-cadmium storage batteries. The necessary storage capacity is 34 ampere hours, which can be provided by 18 pounds of batteries.

9. WEIGHT

Full weight should not exceed 250 pounds.

10. EXPECTED SCIENTIFIC RESULTS

A. Solar Emissions

Variations of solar output would be monitored for a significant portion of the time over a period of a year. Relationships between solar radiations and the ionosphere, the airglow and the aurora should be revealed by the results.

B. Attenuation of Solar Radiation

Measurements of the attenuation of various solar bands during passage of the satellite into or out of the earth's shadow should make possible some conclusions concerning the vertical distribution of atmospheric constituents such as O_3, O_2 and O. With the polar orbit, these data would be obtained initially at latitudes near the north and

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south poles and at all longitudes. As the earth moves around the sun in its orbit, a great variety of attenuation geometries will become possible at all latitudes. The data would be limited somewhat by the fact that the sun has an angular diameter of a half degree. However, the resolving power in altitude should permit significant world-wide comparisons of vertical distributions.

C. Day Airglow

The earth should appear to be black in the wavelength region of ozone absorption 2400 - 2700 A except for radiation by O_2. It is of interest to see if this is really true. Strong airglow emissions expected in the daytime are 3914 A from N_2^+, 7619 from O_2, 6300 from OI and 5893 from Na. All of these are expected to show strong enhancement near the horizon. The heights of these layers could be mapped on a world-wide basis.

D. Zodiacal Light

Detector 42, which measures a broad band of visible light excluding the brightest airglow emissions, can provide data on the zodiacal light in the ecliptic plane. The earth itself will provide the necessary eclipsing disk before the sun.

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E. Night Airglow

There are a number of characteristics of the night airglow that could be determined with the proposed photometers, for each of the several radiations listed. First, the waves and variations that are known to exist in the airglow could be mapped. They are thought to be produced by waves in the circulation of the upper atmosphere, and such a map would give important data bearing on the circulation pattern. Each photometer, as proposed, would scan a curved belt, broadest near the equator and narrowing somewhat at higher latitudes. Each such orbit would cover successive strips of the earth about 30° apart in longitude. Since the earth would be scanned always at the same local time the data would be free from diurnal effects. A second result would be the height of the various airglow layers, from a measurement of the zenith angle of the maximum in luminosity. The region where this could be best accomplished with the proposed arrangement would be in the middle latitudes, both north and south.

A third result would be the study of twilight enhancement for the various emissions, when the satellite passed into twilight at high latitudes, both north and south. The measurements would cover the permanent arctic twilight regions as well as the transitory diurnal twilight.

F. Aurora

This proposed instrumentation offers the possibility of directly comparing the Aurora Borealis and Aurora Australis. The distribution could be plotted relative to the earth's magnetic poles. Correlations could be sought between observations of solar variations and changes in the aurorae. These might be expected to be most conspicuous for the auroral Hα line and for x-rays in the 10 - 150 Kev range. The world-wide distribution for Hα, Lyman-α, x-rays, and the usual auroral emissions could be correlated.

11. PERSONNEL

The experiments proposed are largely a continuation of the photoelectric solar radiation and airglow measurements carried on by the Naval Research Laboratory since 1949 with vertical rocket probes. Principal investigators [redacted]

The results of the NRL program carried on for the past decade include all the currently available data on solar x-rays, the first measurements of Lyman-alpha, the discovery of x-ray emission associated with solar flares, the discovery of resonantly scattered Lyman-alpha in the night sky, and a variety of measurements in various ultraviolet bands between Lyman-alpha and 3000 A. In the field of airglow studies, NRL experiments have established the emission altitudes of the 5577 and 5893 lines and the 2600 to 2900 A band over White Sands, New Mexico. Currently, NRL is providing a Lyman-alpha and x-ray package for IGY satellite #16 and an x-ray package for Vanguard satellite SLV-7. At the same time the laboratory is engaged in a continuing program of rocket probes.

The proposed satellite experiment is based on a broad background of experience in photoelectric photometry above the atmosphere. The wavelength bands chosen are those which appear practical by presently known techniques and that are also of the greatest geophysical interest.

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12. COST BREAKDOWN

It is estimated that 2 years would be required to develop the instrumentation and prepare the flight units to be launched by NASA. The following cost analysis is based on the preparation of five flight packages.

Salaries, Overhead, Indirect costs, 12 men, 2 years	630 K
Detector development and manufacturing (5 sets)	200 K
Test Instrumentation (Optical and Electronic)	150 K
Telemetry (5 units)	75 K
Power Supply (5 units)	300 K
Detector Circuitry (5 units)	100 K
Design and Fabrication of Satellite (5 duplicate packages: 2 prototype, 3 flight units)	600 K
Data Reduction	250 K
Ground station supplies for one year of operation (film, tape, etc.)	75 K
TOTAL	2380 K

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